

“Next - Generation” Thermo-Electric Digital Time Delay Device

Replacement for current Pyrotechnic Delay Cartridges

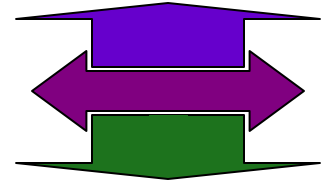
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Aircraft Interior Products
Propulsion Systems
October 25, 2005

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Topics



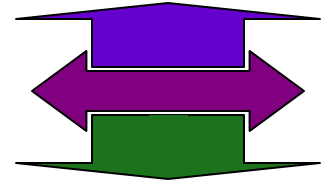
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Introduction



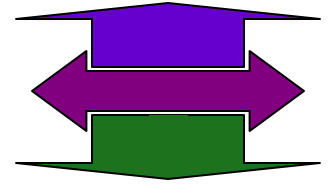
- **What is the digital time delay or DTD?**
 - A new thermo-electric device which can directly replace many existing pyrotechnic time delay cartridges.
 - Requires no external source of power and does not contain batteries.
 - Provides order of magnitude improvement in timing accuracy.
- **How does it operate?**
 - It converts heat energy into electric power using a thermo-electric module.
 - It uses a low power digital micro-controller with a crystal oscillator to accurately measure delay time.

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History



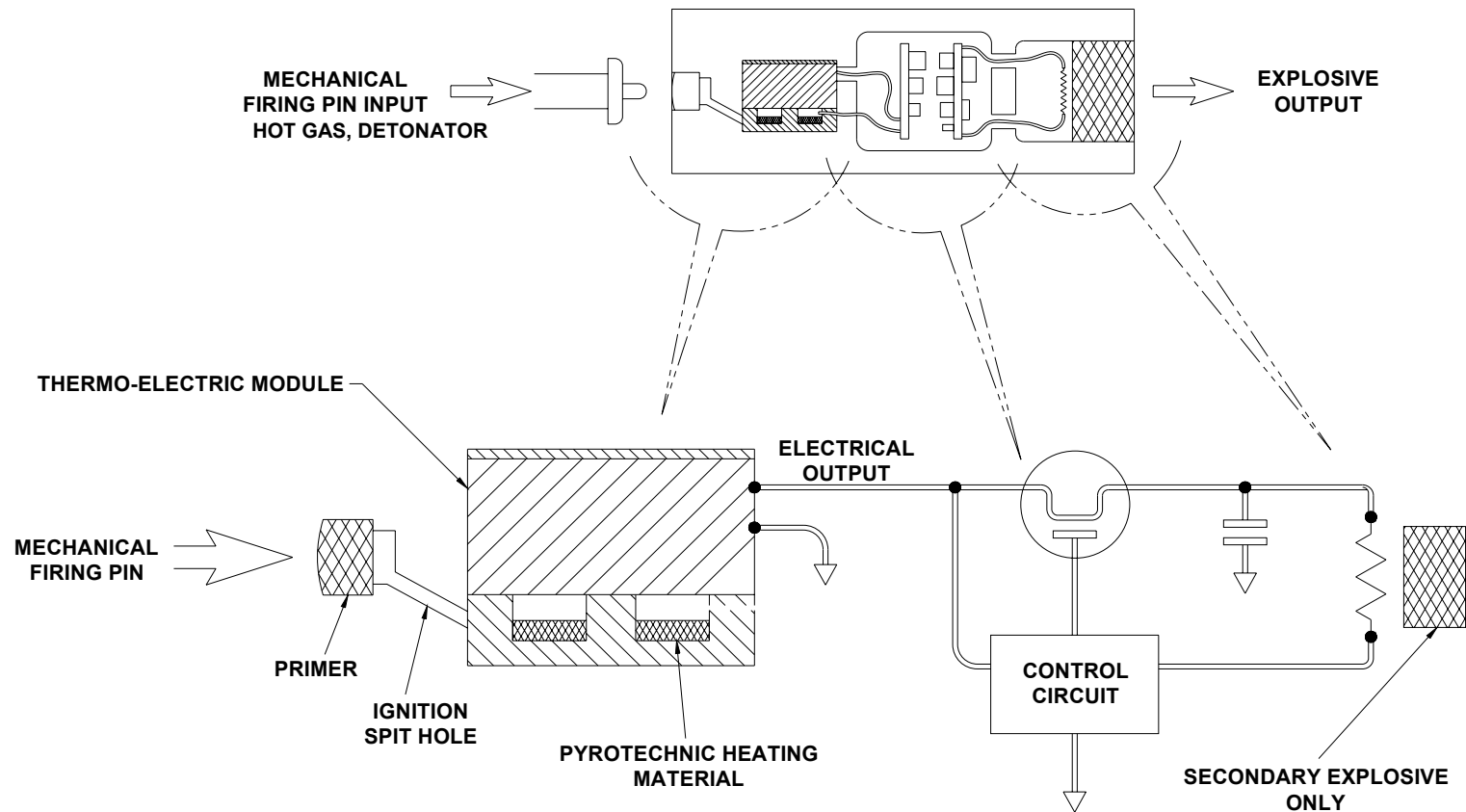
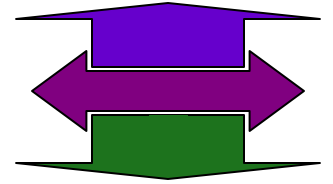
- **3,100 different pyrotechnic delay cartridges configuration are now in use by all Services.**
- **Many of the delay cartridges are man-rated, requiring a high degree of reliability.**
- **Example: There are 112 CAD/PAD cartridges in the B-2 and 222 CAD/PAD devices in the F-14 aircraft,**
- **Majority of these devices could be replaced with the Goodrich *Thermo-Electric Digital Time Delay Device.***

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Operation Diagram

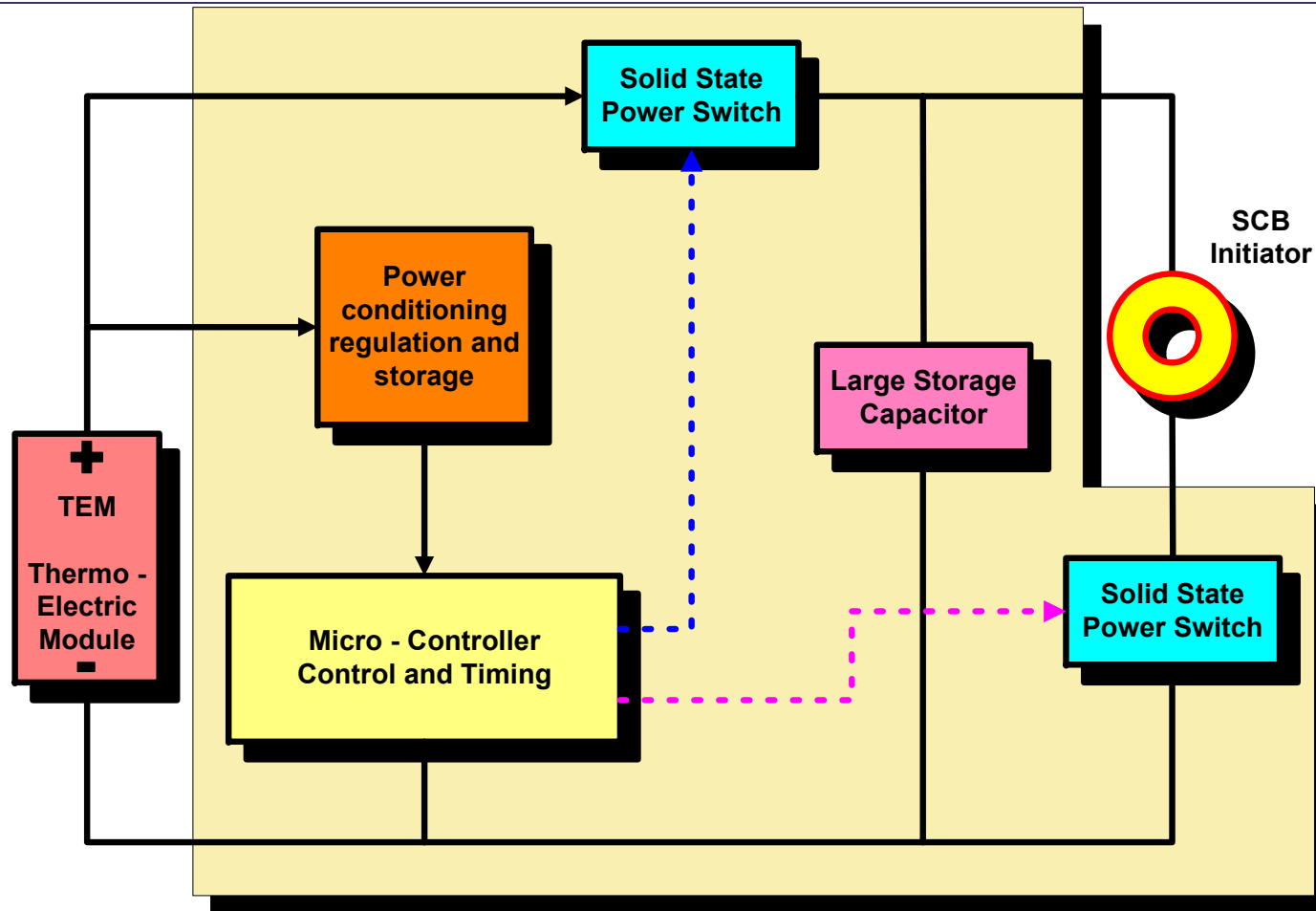
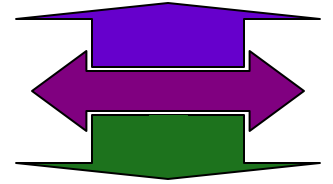


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Block Diagram Electronic Module

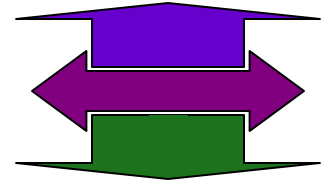


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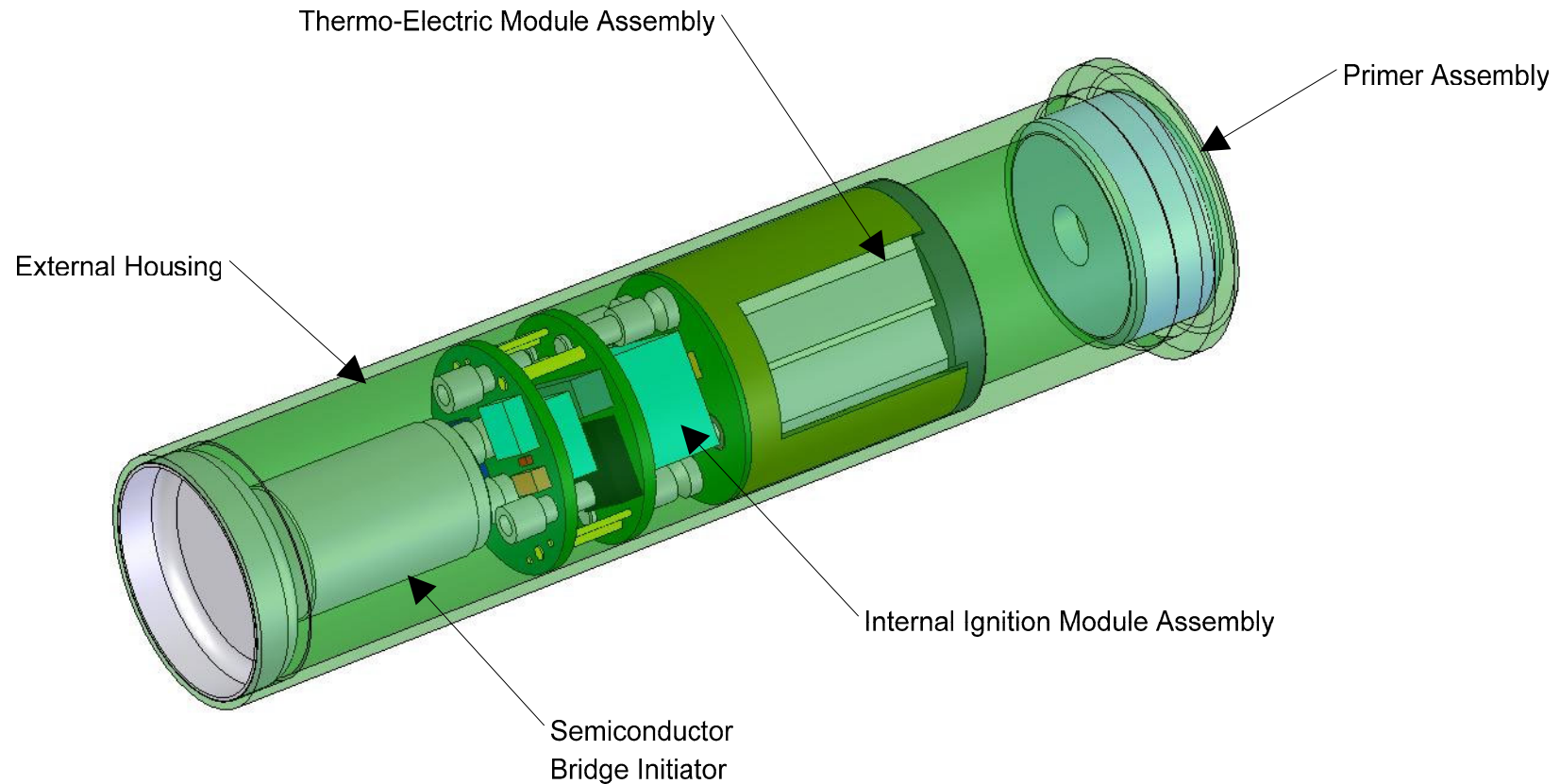
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Proof of Concept Overview



First Generation Digital Time Delay (Size: 1.65 long x .38 diameter)



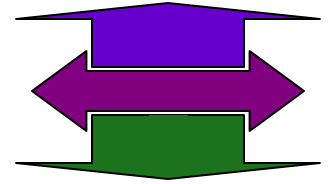
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Specifications



Requirement

Status

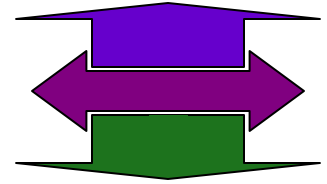
Timing Accuracy of $\pm 1-4\%$ (Over Temperature)	Meets or Exceeds (Proven)
Temperature Range of. -65 °F to +200 °F.	Meets or Exceeds (Proven)
Primary Test time 575ms (300ms-1.34sec delay time tested & proven)	Meets or Exceeds (Proven)
Standard Aircraft Shock and Vibration Levels.	TBD
Minimum 5 Year installed life.	Hermetically sealed dry pyrotechnics – all materials will exceed 5 year life

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Proven Technology



First Generation
Prototypes operated
within a 1%-4%
tolerance range.

Prototype devices also
demonstrated the ease
and simplicity to adjust
the timing controller to
accommodate a variety
of delay times.

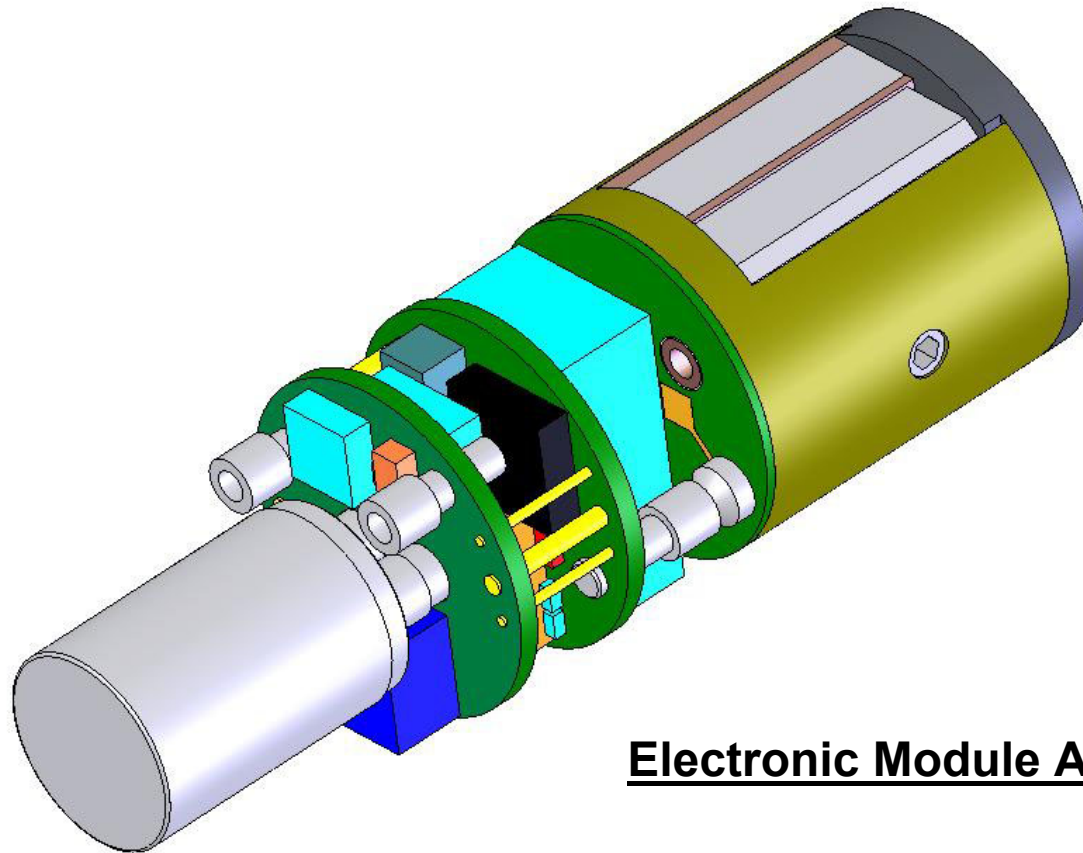
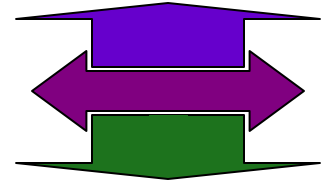
Proof of Concept (5 firings)		
Unit	Temp	Firing Time Goal 575 (milliseconds) ±2% Range (564ms - 586ms)
1	Cold (-65°F)	568
2	Ambient (80°F)	574
3	Hot (200°F)	578
4	Ambient (80°F)	572
5	x	Atrition
First Generation (20 firings)		
Unit	Temp	Firing Time (milliseconds) ±2% Range (564ms - 586ms)
1	Ambient (80°F)	574
2	Ambient (80°F)	580
3	Ambient (80°F)	600
4	Ambient (80°F)	595
5	Ambient (80°F)	591
6	Hot (200°F)	568
7	Hot (200°F)	569
8	Hot (200°F)	579
9	Hot (200°F)	569
10	Hot (200°F)	571
11	Cold (-65°F)	571
12	Cold (-65°F)	573
13	Cold (-65°F)	571
14	Cold (-65°F)	564
15	Ambient	291 (programmed for 300ms)
16	Ambient	1.32 (Programmed for 1.32sec)
17-20	x	Atrition
		1% tolerance range
		2% tolerance range
		3% tolerance range
		4% tolerance range
		Optional Programmed Times

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First Generation Device

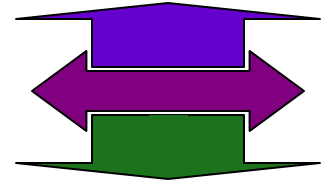


Electronic Module Assembly (EMA)

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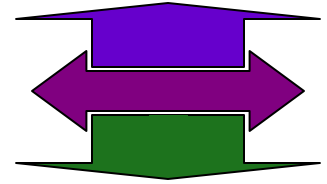


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Next Generation – Integrated Circuitry



The TEM for the Digital Time Delay can either be produced with film technology and/or micro-bulk materials.

Electronic controls will be developed into a single substrate, comprised of advanced thermo-electric materials and imbedded circuitry.

❖ *Film TEM*

High thermal conductivity substrates are increasingly important when the size of the module is decreased. It is also critical to have low contact resistances in the metal-semiconductor interfaces.

❖ *Thick Film TEM*

Thick film technology is very suitable for large-scale production and has the potential to be very cost effective.

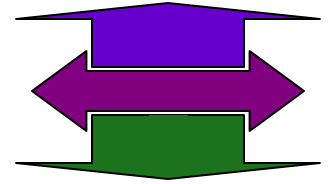
❖ *Micro Bulk TEM*

The processes that would be used in the micro-bulk TEM production are used in the semiconductor industry so the production of the TEM has the potential to be very cost effective.

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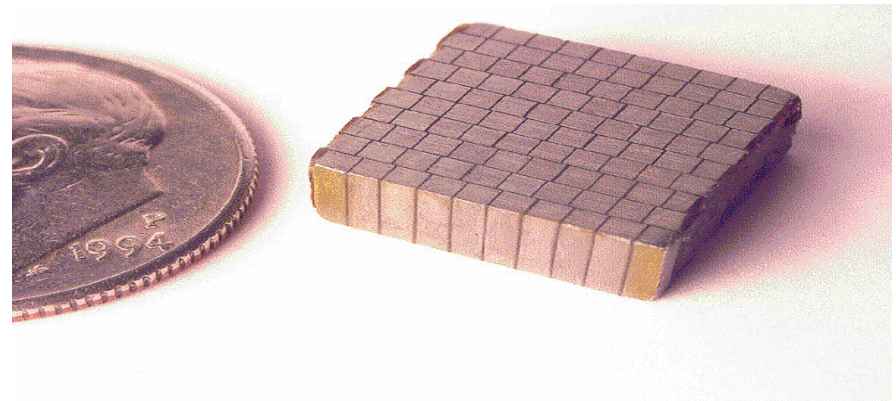
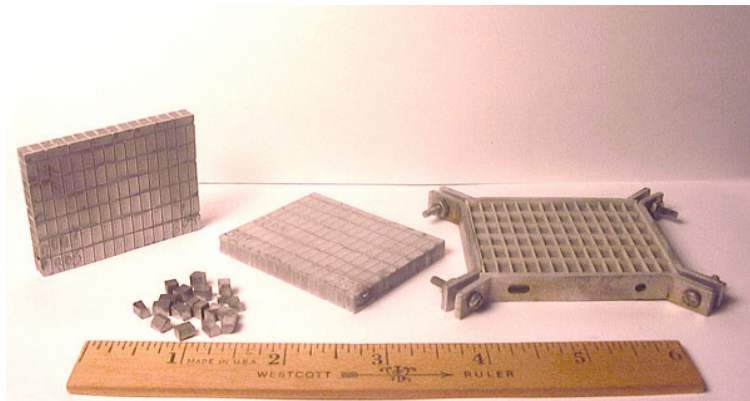
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Goodrich has also secured a relationship with Industry partners to support the development and prototyping process for the next generation thermo-electric module.

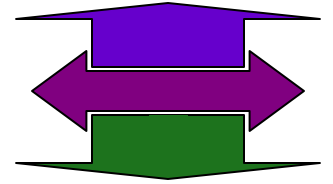
The development parameters for this programs will focus on the development and demonstration of advanced thermoelectric power generators that will deliver higher efficiency and greater reliability.



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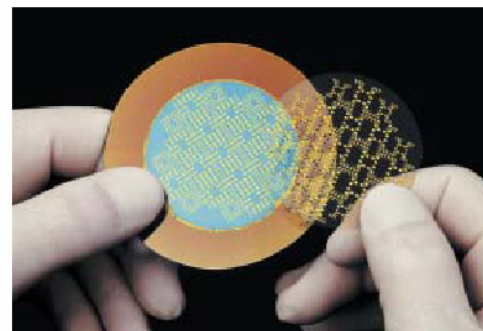


Goodrich has also secured a relationship with a technology developer to support the development and manufacturing process for the next generation thermo-electric materials.

The first significant breakthrough in the field in 40 years is a developed new thermoelectric material that is more than twice as efficient and 23,000 times faster than today's bulk technology which is the existing state of the art material.



High Efficiency
Rapid Temperature Cycling
Space/Weight Premiums

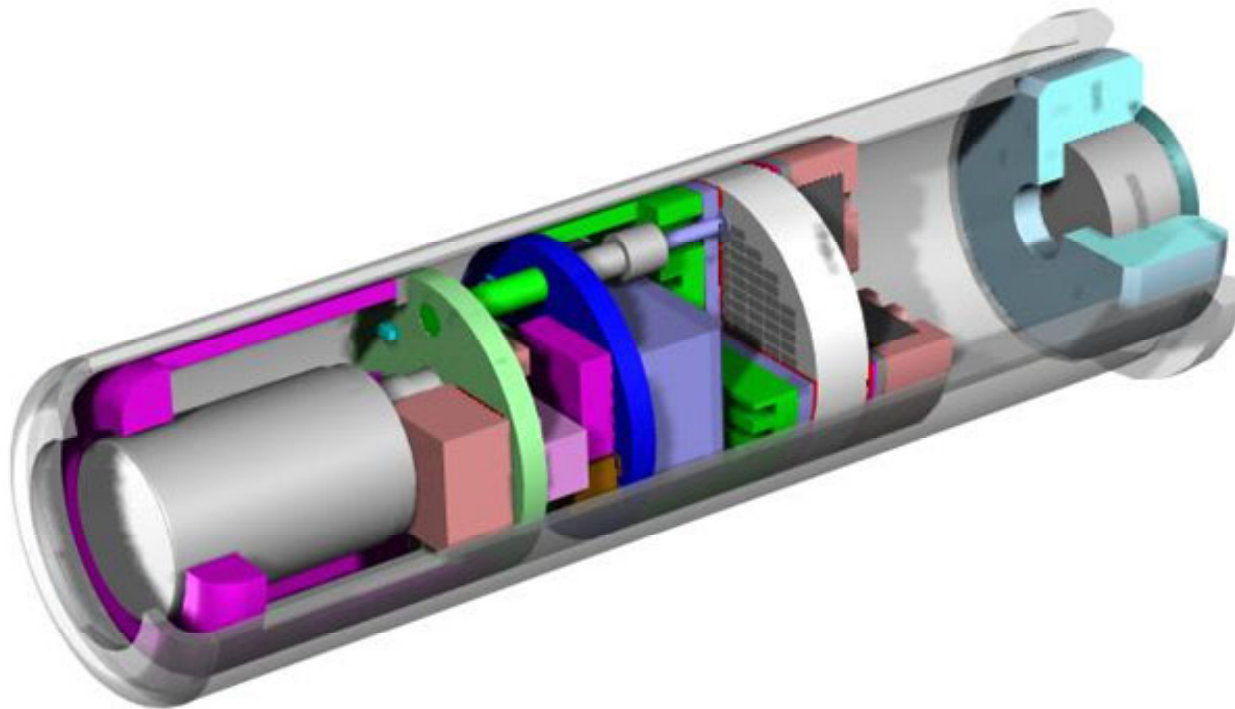
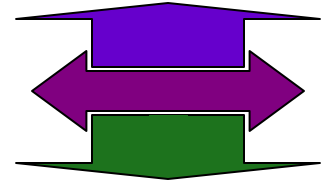


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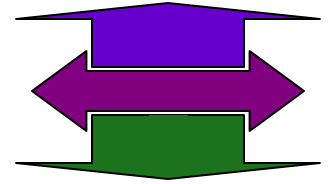
Next-Generation Device



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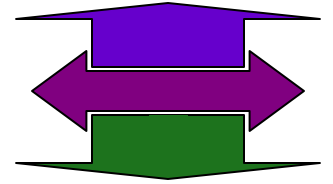
- Goal: to package the technology into a CCU-40 cartridge.
- The CCU-40 cartridge size is .38 in diameter x 1.095 long.
- CCU-40 is the smallest initiator package currently used in the NAVY.
- A circular TEM configuration as show (left) will be used to meet this demand
- The current POC design produced by Goodrich will meet the CCU-35 envelope size.

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Advantages



Advantages over current technologies are as follows:

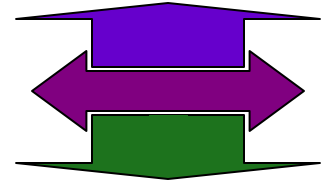
- **Same unit can be programmed for any delay between 0.15 sec to >30 sec**
 - Reduces inventory costs
 - Reduces manufacturing cycle time
- **100% Non-destructive test of time delay components**
- **Removes issues with delay powder column variations, cracks and voids.**
- **Can be configured for other applications:**
 - Field programmable (Manual or electronic)
 - Delay time can be varied based on external stimulus.
 - (I.E. Temperature, pressure, acceleration)

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Envelope Sizes



The current design envelope can be easily adapted to many existing fielded delay cartridges.

Examples of current delay cartridge envelope compatibility:

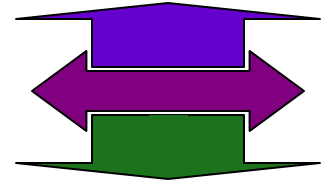
- ❖ *CCU-36/A*
- ❖ *CCU-38/A (With some modifications)*
- ❖ *MU-19*
- ❖ *Size reduction Target Envelope: CCU-40A/A*

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Summary



- ❖ A prototype delay cartridge system with less than $\pm 4\%$ timing error over temperature has been demonstrated by the Goodrich Corporation.
- ❖ No batteries or external source of power is used.
- ❖ Safe, Reliable, Flexible and Long Shelf Life
- ❖ Its small physical size allows “drop in replacement” for many existing applications.
- ❖ Proof of Concept and First Generation design verification units have already been built, tested and proven the basic concept.
- ❖ “Next Generation” cartridge design improvements, size reduction and component cost reduction are now being pursued.
- ❖ Same technology can also be used to generate power from other airborne waste heat sources.

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